



Waterbirds: An Important Bio-Indicator of Ecosystem

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Abstract – Waterbirds serve as an important bio-indicator of ecosystem changes and have been used widely throughout the world. This is because they exhibit conspicuous and meaningful responses to the changes of the environment around them. Other qualities that make them a good bio-indicator are also highlighted. Thus, important information on their biology and ecology are essential to make informed decisions. This is crucial in order to better conserve them and their habitats. Currently they are facing new challenges that arise from continuous development throughout the world. In addition, many endangered species continue to declines and could be extinct if they are not protected and conserved. The development of artificial habitat such as wetlands to compensate natural habitat loss could be an alternative. However, detailed information on the waterbirds and their interactions with the new environment are needed in order to do so. It is further highlighted that few researches have been conducted and focused on the waterbirds particularly in Malaysia. Thus, we encourage more local young scientists to take up this challenge and equip themselves with the right knowledge and necessary skills as well as to remain relevant with the international research standards. Proper planning, funding and focus should also be considered by the government and local authorities to maximize the impact of the country's conservation effort.

Keywords: bio-indicator, conservation, ecosystem, habitat quality, monitoring, waterbirds

Introduction

Monitoring ecosystem's health and quality is a long-term process as they are complex and change slowly. Although it can be costly and time-consuming, the long-term trends that one can obtain from it will help us gain new knowledge and understanding about the environment (Mazzotti et al., 2007). One of the aims of monitoring is to obtain information which can provide early warning of the changes that could negatively affect species or the ecosystem itself (Burger, 2006). However, considering how impractical it is to monitor all of the ecosystem components, a few of them have been used as indicators for wider conditions. These representative components are what we called as bio-indicators (Kushlan, 1993). Bio-indicators are not only representative of particular ecosystems, they are also simple and inexpensive to measure, clearly interpretable and predictable by validated quantitative models, internationally applicable and relevant for the environmental threat (Hakanson, 1999). In addition, bio-indicators should respond to early stages in either exposure or effects condition without disclosing cause-effects relationship (Franzle, 2003). Birds in many cases appear to be more sensitive to environmental contaminants than other vertebrates (Furness, 1993). In particular, the waterbirds have served as sentinel species for various toxicological problems in the environment (Zhang & Ma, 2011) and is expected to continue as one in the foreseeable future.

Waterbirds term encompasses a large group of bird species that feed near or in water. These include shorebirds that forage primarily in saltwater habitat and wading birds that utilize both freshwater and brackish habitats. Wading birds in particular has been increasingly highlighted due to their decreasing pattern worldwide (Wetlands International, 2010). As their presence and abundance can be influent by both local and regional scales, they are continuously being subjected to increasing number of threats

(Finlayson et al., 1992). The loss of inter-tidal habitats or reduction in its size is one of the common issues face by the waterbirds (Szabo et al., 2016). It alters not only their ecology, but causing the reduction in distribution and abundance of dependent species (Brandis et al., 2009). In addition, waterbirds that are dependent on coastal habitats are subjected to continuous exposure from pollutants and habitat degradation (Rahman et al., 2013; Ismail & Rahman, 2016; Rahman et al., 2017).

Waterbirds as Bio-Indicator

Waterbirds are viewed as important bio-indicator because they exhibit conspicuous and meaningful responses to the changes of the wetland habitats. These responses serve as important signs of contamination and deterioration of ecosystem quality. Hence, waterbirds in particular have also been widely used as bio-indicator to highlight problems and other risk that may impact the wetland habitats. The responses they exhibit either by individual or the community can be a useful indicator for the stressors as the species are able to track environmental variations and able to accumulate contaminants along the food chain. This in turn would indicate changes at the lower level of the trophic rank (Furness, 1993; Newman et al., 2007). Moreover, by being directly or indirectly exploited by humans for hunting and fisheries, they indicate their productivity in the nesting area (Miller et al., 1988) and may also reflect the fish stocks (Einoder, 2009). Therefore, there is a continuous need to develop an effective monitoring system using the waterbirds species to provide early warning of the possible danger that may affect our environment (Burger, 2006) particularly our wetland ecosystem. One way to do such assessment is to monitor the birds' presence and activities in a specific habitat.

Hence, waterbirds are still being used as bio-indicators worldwide to help scientist evaluate the status of the environment in which they are found. There are several keys that make them a good indicator of habitat health and quality. These include, but not limited to being long-lived, top predators and able to integrate pollutants over an extensive area through bio-accumulation (Furness, 1993), as well as having wide range of diet selection and habitat utilization (Burger & Gochfeld, 1997). Moreover, their dependency on local resources during migration and breeding has make them a valuable tool to monitor deteriorating habitat quality worldwide, contributing to one of the oldest, established method to assess environment health and quality.

Waterbirds presence and abundance may be affected by both local and regional scales. On the larger scale, variations in bird abundance can be due to population process (e.g. birth and death rates) and migration (Poulin et al., 1993). Waterbirds' abundance can also be localized depending on the habitat characteristics such as water depth, physical and chemical conditions and water body size (Wiens, 1989). For example, a study by Hoyer and Candfield (1994) found that wetland with high nutrient level or eutrophic characteristic tend to have higher bird abundances and species richness. Other natural processes that can shape bird population include density-dependence, environmental stochasticity and competition, as summarized by Fasola et al. (2009). It is important to identify these factors in order to manage and control waterbirds population. Waterbirds have long been the attention and subject of global research due to the ease of assessing the population.

The waterbirds may not only used to monitor local food webs. Migratory waterbirds can also be used to compare exposure in different regions (Pereira et al., 2009) and because of large amounts of data have been collected for waterbirds population, monitoring the environment became easier. Coastal birds like the Milky storks (*Mycteria cinerea*) can be good bio-indicators because they reveal current environmental exposure and respond relatively rapid to contamination events (O'Halloran et al., 2003). The species has been reported to depend on the mangroves exclusively for nesting, but they can forage elsewhere (Wells, 1999). Moreover, there are a number of studies that suggest improvement of habitat health and quality will attract more waterbirds to the area (Perez-Garcia et al., 2014; Van Roomen et al., 2006).

Importance of Wetlands to The Waterbirds Community

Wetlands are transitional areas between the aquatic zone and terrestrial zone which possess a diverse flora and fauna species and is a biologically high productive ecosystem. There are two general types of wetlands; they are the coastal or tidal wetland, and inland or non-tidal wetland. The plants and

animals in the coastal wetlands are very much influenced by the tidal actions. The high salinity and fluctuation in water level make it hard for most of the living organisms to live in the area. As a result, coastal wetland has a low diversity of species due to many species are not salt tolerant, particularly the plant species. Mudflat and sandy flats are the two common examples of coastal wetland. Meanwhile, inland wetland is located in the riparian zone where rivers, streams, lakes and ponds are the main water body for the habitat. Marshes and wet meadows are the two examples.

According to the Water and Rivers Commission (2000), historically, wetlands were viewed as wastelands, breeding grounds for mosquitoes and opportunities for land reclamation and tip sites. This has led to the destruction and degradation of various wetland ecosystems, which in time decline at a rapid rate. It is not until later that we discovered the importance of the wetlands, which regulate ecosystem services that are crucial to both human and animal (Bobbink et al., 2006). They play an essential role for regulating, filtering and treating water bodies as well providing variety of habitats for plants and animals like birds (e.g. herons, storks, egrets) to live in. It provides abundance of food sources to various organisms including waterbirds (e.g. Grey heron, Milky stork, Lesser adjutant). The waterbirds in general has become one of the main occupants in this habitat. They utilized the area for feeding, roosting and if favourable would establish and breed in the area. The presence of waterbirds community is also a good sign for the newly created wetland as it is able to attract diverse species of the birds to utilize this area (Ismail et al., 2012).

Wetlands with the greatest diversity of flora or where permanent water exists often has the highest number of waterbirds (Balla, 1994). Some waterbirds may forage dependently on specific wetland habitats (e.g. herons). Hence, stresses the importance of diversity in wetland habitat. Wetland is also important as stopover site for migratory birds (e.g. Whimbrel, Common redshank, etc.). Migratory birds from the northern hemisphere travel every year to the southern part of the hemisphere to refuel, feed, and rest in available wetlands during winter. Despite the importance of the wetlands, they are among the world's most vulnerable ecosystems. According to BirdLife International (2010), at least 42% of migratory waterbird populations are declining due to the loss of wetlands along major flyways area. The protection and conservation of the wetlands are therefore important and very much needed.

Currently, there are about 91 wetlands in Malaysia which 55 are in Peninsular Malaysia, and 18 each in Sabah and Sarawak respectively, encompassing various islands, coastal wetlands and inland wetlands that support diverse group of waterbirds and migratory birds as well as other flora and fauna (Shukor, 2005). Historically, Malaysian Wetland Working Group (1986) reported that there are at least ten major categories of wetlands in Malaysia. These include the mangroves, mudflats, nipah swamps, freshwater swamp forest, peat swamp forest, natural lakes, oxbow lakes, rivers, marshes and wet rice paddies. Later in 1999, Malaysia's National Wetland Policy re-classified them into three main categories; marine and coastal wetlands, inland/ freshwater wetlands and man-made wetlands (MNS, 2018). These wetlands house a number of endangered waterbirds species like the infamous Milky stork (*Mycteria cinerea*) and Lesser adjutant (*Leptoptilos javanicus*) (Ismail & Rahman, 2012a). These two species are currently vulnerable to extinction (BirdLife International, 2010).

Furthermore, the protection of natural habitats like the well-known Ramsar sites around the world is positively correlated with the waterbirds presence. Protected habitats help conserve the ecosystem by providing shelter, food, raw materials, genetic materials, a barrier against disasters, a stable source of resources and many other ecosystem goods and services that play an important role for survival of species, people and countries to adapt to climate change (Mansourian et al., 2009). Kleijn et al. (2014) stated that in their reviews of 21 years data after the designation of 200 Moroccan wetlands as Ramsar sites, the waterbirds and species richness increased more rapidly as compared to non-designated habitats. The findings further demonstrate the importance and usefulness of waterbirds to track environmental changes or vice versa, proving the close relationship between those two.

Issue Faced Caused by The Waterbirds Community

Continuous disturbances and pressures by human had forced these waterbirds to migrate to other area. One particular example is the Black-crowned Night heron (*Nycticorax nycticorax*). The species was

once recorded to exist only at Kuala Gula, Perak, in the west coast of Peninsular Malaysia (Medway & Lim, 1970). However, the current distribution of this Night heron population is no longer restricted to coastal or mangrove area. The birds have migrated deeper into the Peninsular probably due to human and habitat pressures, and availability of suitable inland habitat. According to the four years mid-winter waterfowl censuses from 1990 to 1993, the Night heron was among the highest number of birds recorded in eight states within the Peninsular Malaysia; Perlis, Kedah, Penang, Perak, Selangor, Negeri Sembilan and Johor (Siti-Hawa & Ismail, 1994). The actual numbers of colonies established and their locations however, are still unknown. More colonies can now be observed and located in the wetland and forest areas at Putrajaya and Selangor (Ismail & Rahman, 2012c; Ismail et al., 2012). These include suburban area at Rawang, Paya Indah Wetlands and Ulu Kelang, Ampang. Considering the past 30 years since they were first recorded in 1970, Night heron numbers and distribution had definitely increased throughout Peninsular Malaysia (Ismail & Rahman, 2012b). Other waterbirds species have also been reported to be negatively impacted by human disturbance (Ramli & Norazlimi, 2017). This example shows on how human and habitat pressures play their role for the distribution and survival of waterbirds population.

Environmental factors are also important for shaping waterbirds population. Waterbirds population community may be affected either directly or indirectly depending on the scale, intensity or magnitude of the factor. Examples of direct changes include alteration of nesting and foraging behaviour by climate (Ismail & Rahman, 2013; Zainul-Abidin et al., 2017). In Italy, the number of nesting Squacco heron and Black-crowned night heron were positively affected by the increasing rainfall pattern (Fasola et al., 2009). Moreover, there were evidences suggesting temperature affects several breeding parameters such as arrival time, as well as breeding phenology of birds (Tryjanowski et al., 2002; Mitrus, 2003; Ludwig et al., 2006). Climate changes also indirectly affect waterbirds population by altering or reducing available habitat for the birds. Due to the distinctive and observable responses exhibited by waterbirds to environmental changes, they have been proposed as bio-indicator for both seasonal and climatic changes (Ajonina & Usongo, 2001; Ajonina et al., 2009). According to Finlayson et al. (2006), some of the changes that will occur due to climate variability include the loss of inter-tidal habitats and increased salinity of coastal freshwater habitats as sea levels rise, reduction in the extent of wetlands and duration of flooding in arid and semi-arid areas and the loss of wetland breeding habitats in Arctic and sub-Arctic areas as temperatures increase, expanding boreal forests and forest fires. This is where waterbirds can play a role as monitoring agent, so that swift action can be taken to minimize those impacts mentioned above.

Prolong stay of waterbirds population in certain area however is not always advantageous. If left unchecked, the habitat quality may be compromised as a result of abundance of birds' faecal, overfishing, noise and visual disturbance by the large aggregation of the birds (Marquiss, 1993). Hence, human interactions with waterbirds will become more complex through natural and human-caused events that in time deteriorate the environment's quality. Human-waterbirds conflict may also arise later as they interfere with human activity as a way to compensate the loss of their habitat value. For instance, herons in some place are regarded as threats to the aquaculture industry (Hoy, 2017). This waterbird feed on fish and other aquatic invertebrates bred in captivity. Thus, killing this waterbirds were done extensively at that time in Europe as described by Marquiss (1993); large numbers of herons have been killed through human agency as they feed on aquacultures. This act slowly becomes less intense in later period as the waterbird' numbers are dwindling. However, Marquiss (1993) also stated that although waterbirds killing still continues today, it is much more localized.

Increased number of waterbirds population in urban areas could also pose several threats to both human and animals. The bodily discharges of infected birds such as deposition of faecal matters and secretions from nose, mouth and eyes can transmit pathogens and viruses that are lethal to organisms that come in contact with them (Peiris et al., 2007). Common examples are avian influenza which affect human and Newcastle Disease Virus which infect other birds (Alexander & Capua, 2009). Migrating birds have been known to circulate highly pathogenic avian influenza H5N1 since 1996, starting at eastern Asia and later spreads to other parts of the world (Newman et al., 2009). Migratory

waterbirds with the disease tend to spread it throughout its range and it could then be picked by other waterbirds that further transmit the disease elsewhere. Monitoring this bird's migration has become very important to minimize the risk and to do this accurately, we need to understand the biology and ecology of the species involved.

With accelerating decrease of available habitat to forage and nest on, the waterbirds have become an opportunist species as they use whatever resources they can find within their range (Ismail & Rahman, 2012c). In Malaysia, many abandoned old mines, lakes and ponds have been utilized by the waterbirds for their daily activities. For instance, the construction of Putrajaya Wetlands has attracted several waterbirds species to utilize the area (Ismail & Rahman, 2012c; Ismail et al., 2012). The wetland area is protected and thus food supplies like fishes and other invertebrates are expected to exist in abundance. The increase of birds' immigration and density in the area may cause problems if left unchecked and thus need to be monitored.

Waterbirds Studies in Malaysia and Their Future

Table 1 shows the published studies (in both local and international scientific journals) that highlighted waterbirds in Malaysia, between the year 2010 and 2016. In general, researches on waterbirds are still few and mostly focused for obtaining basic information on species' diversity and distribution i.e. data from inventory or checklist activity. Hence, mixed species were highlighted in most of the studies instead of individual one. Analysis-wise, most studies employed standard or conventional classical analyses to report on their data with the exception of the bio-logging technique used on the Milky stork by Ismail et al. (2012). The finding also shows that we are still lacking on important information relating to the species' biology and ecology as a whole, which includes both common and endangered species in the country. In addition, we need a long-term set of data and with a new approach to analyze them using non-classical analysis to get a more detailed and updated results, so that can help improve current conservation effort. Without these, it may affect future waterbirds conservation in Malaysia such as in the case of the Milky stork. The Milky stork (*Mycteria cinerea*) is one of the endangered waterbird species in the country that currently being re-introduced back into the wild (Ismail et al., 2010). According to Ismail and Rahman (2016), its rehabilitation and conservation efforts are nationally recognized and supported by the Malaysian government. However, the main reason for the species rapid decline remains speculative as no scientific data are available to back them up. As such, the re-introduction program was conducted as a trial-and-error process in order to learn and later have it improved. This stems from the lack of fundamental knowledge on the species' biology and ecology prior to its decline. Nonetheless, the programme is still considered as successful at the moment as a healthy and viable number of Milky stork's individuals have been established at Kuala Gula, Perak (Ismail & Rahman, 2016). As such, there are still countless opportunities for local scientists to study the subject and help in the species conservation. For example, we still need to understand the adaptation and behaviour of the re-introduced population in relation to the anthropogenic activity in the area. This will help responsible authorities at Kuala Gula for improving the management of the population and its habitat in the future.

Table 1: Published studies on waterbirds in Malaysia between 2010 and 2016.

	Species	Habitat Location	Type of studies	Authors
1	Mixed species	Paya Indah Wetlands	Density & Diversity	Rajpar & Zakaria, 2010
2	Mixed species	Paya Indah Wetlands	Environmental factors and distribution	Rajpar & Zakaria, 2011
3	Milky Stork (<i>Mycteria cinerea</i>)	Zoo Negara	Daily activity/ Bio-logging	Ismail et al. 2012
4	Night Heron (<i>Nycticorax nycticorax</i>)	Rawang, Selangor	Nesting activity and disturbance	Ismail & Rahman, 2012b
5	Mixed species	Putrajaya Wetlands	Diversity and Feeding Guild	Ismail et al. 2012
6	Mixed species	Putrajaya Wetlands	Population Dynamic	Ismail & Rahman, 2012c
7	Mixed species	Putrajaya Wetlands	Environmental factors and distribution	Ismail & Rahman, 2013
8	Milky Stork (<i>Mycteria cinerea</i>)	Kuala Gula Bird Sanctuary, Perak	Pollution/ Eco-toxicology	Rahman et al. 2013
9	Mixed species	Putrajaya Wetlands	Density & Diversity	Zakaria & Rajpar, 2013
10	Mixed species	Paya Indah Wetlands	Environmental factors and distribution	Rajpar & Zakaria, 2014
11	Mixed species	Putrajaya Wetlands	Density & Diversity	Rajpar & Zakaria, 2013
12	Mixed species	Tanjung Karang's mangroves & Peat swamps	Environmental factors and distribution	Sulai et al. 2015
13	Milky Stork (<i>Mycteria cinerea</i>)	Kuala Gula Bird Sanctuary, Perak	Foraging activity & Disturbances	Ismail & Rahman, 2016
14	Asian Openbill (<i>Anastomus oscitans</i>)	Peninsular Malaysia	Distribution and habitat selection	Zainul-Abidin et al. 2017
15	Mixed species	Pantai Jeram & Remis, Selangor	Disturbance and abundance	Ramli & Norazlimi, 2017

Another potential study is related to the increasing interest of developing or creating artificial habitat like wetlands. Artificial wetlands have played important roles for providing alternative sites for waterbirds to forage, roost and even nest (Ismail et al. 2012). For instance, artificial wetlands are being created all over the world as they play an essential role for regulating, filtering and treating the water bodies. They also provide variety of habitats for the plants and other animals like waterbirds to live in. Although artificial wetlands may only be a temporary relief to waterbirds' community in time of stress and food scarcity, with the continuous losses of natural wetlands around the world, the value of artificial ones to the waterbirds become more apparent (Czech & Parsons, 2002). In addition, with good knowledge about the community relationship and important of wetlands features, the ecology of newly created or restored wetlands can be improved (Moreno et al., 2008). For instance, the effect of migration of waterbirds into a newly developed habitat such as wetlands could be studied. Such information is important to assess and sustainably manage the habitat. Putrajaya Wetlands is a good example of an artificial habitat that was successfully developed and able to sustain a healthy number of waterbirds to this day (Ismail & Rahman, 2012c). It serves as a good location for young scientists to further their researches that focus on waterbirds.

Apart from new studies or researches, continuous monitoring program on both waterbirds and their habitats are essential. This is to reveal any changes of this transforming ecosystem within a specific time-range. Moreover, there is a need to understand habitat requirement of the waterbirds by

developing a good model to be incorporated into the current wetland's management plan. This can also be one of good research opportunities for the local scientists as we are still lacking in one. With a good understanding about the waterbirds' biology and ecology, it would certainly be advantageous to the management and conservation processes. Moreover, with the right decision, it could be one of the big assets for attracting tourist to further promote our wetlands and parks as wildlife and nature eco-centre. Last but not least, cases like the Milky stork and other endangered species highlight the importance for studying our waterbird species prior to their extinction in the wild.

Therefore, local scientists from various disciplines need to work together to collect relevant information to help with future waterbirds conservation efforts. With continuous development of coastal areas, the waterbirds' habitats will continue to decline and be degraded. As such, more challenges are expected for conserving our wildlife species in general and waterbirds in particular. Thus, our scientists need to be well-prepared, highly skilled and knowledgeable to help solve both current and future conservation issues. Capacity building i.e. training and recruiting of more young scientists in related field, as well as development of research institute with appropriate equipments are a must. Without proper planning, sufficient funding and focus given by the authority to support this mission, our effort to conserve our wildlife population will remain scattered and often individually-oriented with minimal impact to the society.

Conclusion

Waterbirds serve as an important bio-indicator of the ecosystem changes and have been used widely throughout the world. Important information on their biology and ecology are essential to make informed decision in order to better conserve them and their habitats. However, few researches have been conducted and focused on the waterbirds particularly in Malaysia. The authors encourage local young scientists to take up this challenge and equip themselves with the right knowledge and skills necessary, as well as to remain relevant with the international research standards. Proper planning, funding and focus should also be considered by the government and local authorities to maximize the impact of the country's conservation effort.

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